THE SPRING RESEARCH AND MANUFACTURERS' ASSOCIATION

AN EVALUATION OF THE PERFORMANCE OF COMMERCIAL ON-LINE LOW TEMPERATURE HEAT TREATMENT UNITS

Report No 401

by

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SUMMARY

Two types of on-line low temperature heat treatment units are in general use today - a horizontal conveyor belt type and a vertical spiral type. This report gives details of the practical implications of using this method of heat treatment and shows the advantages and disadvantages when compared with conventional batch type heat treatment. For the batch of torsion springs used for this evaluation, both types of on-line unit worked satisfactorily, and enabled heat treatment times to be reduced for the conventional 30 minutes to approximately 2 minutes.

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INTRODUCTION

Considerable usage is made of on-line low temperature heat treatment (LTHT) units in Japan and increasing usage is reported from USA and West Germany. SRAMA reported as early as 1972 on the feasibility of rapid LTHT[1] of springs and concluded that conventional LTHT of 20-40 minutes duration in large ovens could be reduced drastically. More recently a survey of the commercially available on-line LTHT ovens was reported.[2] Nonetheless on-line LTHT units are very seldom used by British springmakers, and even then some units are used at their slowest speed in order to simulate as nearly as possible conventional LTHT of springs.

The purpose of this report is to advise members of the practical and commercial implications of using on-line LTHT units. Trials have been conducted in makers plants to compare the performance of the two basic designs of commercially available on-line LTHT units, with conventional LTHT procedures.

MATERIALS AND EXPERIMENTAL METHODS

A single design and batch of torsion springs was used in order to evaluate the practical effectiveness of on-line LTHT units. Torsion springs were chosen for this purpose because the leg movement of torsion springs with varying LTHT temperature is a good and accurate means of assessing LTHT performance.[3] The design of these springs is shown below, and the relative leg position of the springs was thoroughly checked to ensure that a consistent batch had been obtained.

Torsion Spring Design

Wire grade	BS 1408 B3 Pre-galvanised
Wire diameter	1.22 mm
Outside diameter	11.32 mm
No of coils	11 turns + 344^{o}

The response of these springs to LTHT was evaluated by heat treating springs for 30 minutes in SRAMA's ovens at accurately known temperatures. The response was quantified solely in terms of leg movement, which characterised the conventional LTHT temperature.

Having established the effect of conventional LTHT on these springs, further springs from this same batch were taken to two standard on-line LTHT units located in UK springmaking firms and trials were conducted. A previous survey[2] had shown that there are two basic designs of on-line LTHT units - a conveyor type on which springs are carried on a horizontal conveyor through a hot zone, and a spiral type in which springs are carried slowly down a vibrating spiral tube located within a vertical free standing furnace. All commercially available units of each type are electrically heated, and thermostatically controlled.

Specifically, the two on-line LTHT units evaluated were:-

a) Conveyor type — Gasden Ro Model TTBC-210

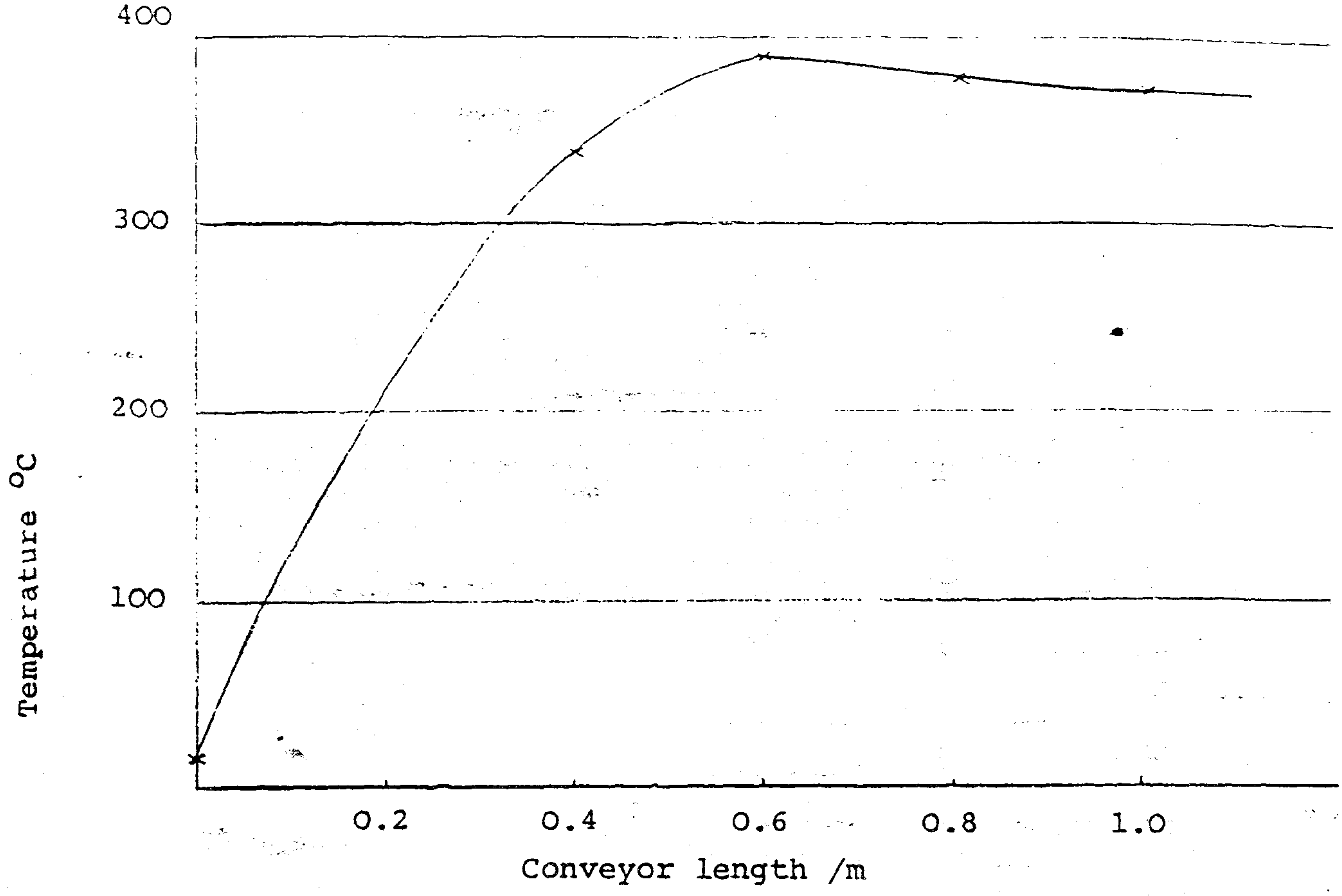
b) Spiral type — Adnik MEC Model 1-500

Trials were conducted with these units with a view to evaluating their performance at a range of temperature and speed settings, in order to gauge the consistency of performance. Batches of ten springs were used at each temperature and speed setting.

RESULTS

The temperature attained by the units was checked using a portable digital thermometer and thermocouple and was found to correspond accurately with the set temperature. The throughput speed setting was checked against the actual time taken for springs to travel through the units. The Gasden Ro gave a consistent performance, but the actual throughput was about 50% longer than the setting on the machine. The Adnik did not give a consistent performance in as much as the setting (seals 1-10) did not give the same throughput time each time it was set at a particular speed. The erratic performance of this model may have been exacerbated by weld repairs to a worn cam.

The actual thermal history of a commercial batch of springs undergoing rapid LTHT of 400°C for 2 minutes (thoughput setting) on the Gasden Ro oven is illustrated in Fig 1. Clearly the temperature is not uniform through the furnace, and a similar temperature/time history would be anticipated for springs treated in the spiral type units.



Nonetheless both machines were operated to give similar throughput speeds and temperature setting and Table 1 gives results of the wind-up of batches of ten springs.

From this table it can be seen that conventional LTHT at 250°C for 30 minutes is approximately equivalent to rapid LTHT of 400°C for 2 minutes; or about 330°C for 3 minutes.

The variation in the relative leg position was checked by calculating the standard deviation of the ten measurements made on each batch. It was found that the standard deviation was three degrees initially, and as a result of both conventional and rapid LTHT this standard deviation increased to between 5 and 8 after LTHT at 400°C.

PRACTICAL/COMMERCIAL CONSIDERATIONS

On-line LTHT units may be used coupled to automatic spring coiling machines, but there are practical and commercial considerations before accomplishing this, namely:-

1. Sufficient space for the on-line unit is needed adjacent to the coiling machine, and the conveyor type units require more space than the spiral type.

2. The volume capacity of the on-line LTHT unit must be compatible with the volume of springs produced by the coiler. If the on-line unit has too small a capacity it will be necessary to slow down the coiler, even when the unit is operating at its maximum output speed. Setting of the unit is not a long job compared with setting times for coilers, but account will need to be made of this factor, and will make the unit more attractive for longer production runs.

3. On-line LTHT units cost in excess of four thousand pounds sterling to buy, and the models considered here have fairly poor thermal efficiency and use the most expensive heating fuel - electricity.

All of the commercially available on-line LTHT units except one are of Japanese origin. One of the Japanese models has sole European import agents, hence prospective purchasers have to wait while the units are imported to Europe, and are then re-exported to Britain. This entails long delivery delays especially for any spares that are required. The manufacturers and import agents for on-line LTHT units at the date of this report are as follows:-

Manufacturer	Country of Origin	Type	No of Models	Import Agent
Adnik/MEC	Japan	Spiral	2	Lechant et Kanel
"	"	Conveyor	5	"
Gasden Ro	"	Conveyor	10	Heath Springs
SD Ovens	"	Spiral	6	Frank Whitelegg (Schenker)
Viturbomax	Italy	Spiral	3	-

It should be noted that the Wafios model mentioned previously[2] is no longer available.

DISCUSSION

On-line LTHT unit manufacturers claim that numerous advantages will accrue to the springmaker when operating these units. These advantages are considered here and compared with the findings of this investigation where possible.

1. Precise Control. This appears to be true in terms of temperature control, but there are doubts about precise control of throughput time when operating spiral type units.

2. Less Handling. If the on-line LTHT unit is coupled to an automatic spring coiling machine, then collection of as-coiled springs, transport and loading of those springs to the conventional LTHT oven is eliminated.

3. No Spring Tangling. It is possible to collect springs from the on-line LTHT on a conveyor, or on sticky paper and tangling is virtually eliminated.

4. Rapid Operation. Heat treatment of springs may be accomplished in about 2 minutes using these units and this may be very valuable when setting an automatic coiler. Also small adjustments to throughput or dimension (eg torsion spring leg angle) rather than altering the set up of the automatic coiler. However if the coiler produces a greater specific volume of springs than the on-line LTHT unit can process, the coiler will have to be slowed down.

5. Facilitates SPC. It is presumed that coiling and LTHT are considered one operation and dimensional and/or load measurements may be made once rather than twice when operating an SPC production/quality control system.

6. Lower Costs. The relatively high capital and running costs involved with on-line LTHT units mean that the only feasible way to reduce a springmakers' operating costs with these units is to operate them at maximum throughput speed. Maximum utilisation of the unit will be vital if the capital costs/interest charges are to be offset against reduced energy costs and reduced labour costs through less spring handling.

CONCLUSION

It has been shown on one type of torsion spring that commercially available on-line LTHT units are capable of producing a dimensionally consistent spring product. Conventional LTHT of 250°C/300°C for 30 minutes may be replaced by rapid LTHT of 400°C for 2 minutes using either the Gasden R or Adnik/MEC models considered here.

REFERENCES

1. Graves, G B, and Heap, J M A, "Rapid Low Temperature Heat Treatment of Cold Drawn Steel Wire and Springs", The Spring Journal No 106, March 1972 pp 16-27.

2. Graves, G B, "A Note of Heat Treatment Equipment Suitable for the Rapid Low Temperature Heat Treatment of Light Springs", SRAMA Report No 355.

3. M O'Malley, "The Effet of Low Temperature Heat Treatment on the Wind Up/Down and Elastic Limit of Torsion and Extension Springs", SRAMA Report No 396.

Table 1

TORSION SPRING MOVEMENT AS A RESULT OF LTHT

Mean results for batches of ten springs

Set Temperature $^\circ$C	Throughput time for LTHT unit									
	2 min		3-3½ min		4-5 min		7-9 min		30 min	
	GR	A	GR	A	GR	A	GR	A	A	C
20									0°	0°
230						32°				44°
250			24°		35°					48°
300	27°	27°	37°	47°	54°	55°				60°
350	36°	33°	52°	57°	66°	60°		67°		76°
400	58°	48°	68°	68°	84°	76°			93°	97°

Where GR denotes Gasden Ro unit (throughput is set time)
A denotes Adnik unit (throughput is actual time)
C denotes Conventional LTHT at SRAMA